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Received January 2, 1985

The Journal of General Psychology, 112(2), 201–210

Learning and Retrieval Rate of Words Presented Auditorily and Visually

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ABSTRACT. Mode of presentation (visual or auditory) of a multitrial free recall test is stressed as an important factor in improving the diagnosis of certain neurological patients. For further use in neuropsychological research, an experiment was carried out using normal subjects, in which the effects of presentation mode and order of modality were investigated. There were no differential effects of these variables on several parameters, such as the number of words recalled and the learning curve. The time needed for the responses in immediate recall was the same in both auditory and visual conditions. In delayed recall, however, the interresponse times were significantly shorter when words had been presented auditorily than when presented visually. The results are discussed in light of further application in the field of neuropsychology.

MULTITRIAL FREE RECALL TESTS offer a useful paradigm for research into verbal memory processes (Engle, Clark, & Cathcart, 1980; Penney, 1975). These learning tests have proven their value not only in the psychological laboratory but also in clinical neuropsychological practice in the assessment of patients with cognitive deficits (Lezak, 1976; Luria, 1976; Rey, 1964). Word-learning tests in which the number of items to be recalled exceed short-term memory (STM) capacity (e.g., a 15-word learning test) are tools to examine the organization of verbal memory. Healthy subjects use strategies such as rehearsal and semantic clustering to facilitate the learning process (Sternberg & Tulving, 1977). Consequently, the number of

The research presented here was supported by Grant No. 560-264-010 from the Netherlands Organization for the Advancement of Pure Research.

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items that are correctly recalled increases with trials and reaches an asymptote within five trials. Patients with frontal neocortical dysfunctions characteristically lack organizing ability and have a flat learning curve: The number of words recalled does not increase with the number of trials (Luria, 1976). These frontal patients show many errors of repetition and sometimes a rigid, stereotyped order of recall. Storage, however, does not seem to be affected because their performance on a word-recognition test is normal (Luria, 1976; Jolles, in preparation). Patients who suffer from lesions in the limbic system (e.g., Korsakoff's syndrome) have a similar plateau-shaped curve. Their performance is due to great instability and to reciprocal inhibition of traces rather than to inactivity or stereotyped reactions and the absent use of strategies. Patients with damage in the posterior neocortex characteristically show learning in a multitrial learning test, but they reach an asymptote sooner than do healthy subjects. According to several authors, their memory deficits are modality and material specific (e.g., specific for words presented auditorily or faces presented visually). For instance, Luria (1976, 1980) noted that patients with a lesion in the left temporal lobe failed on the auditory version of his 10-word learning test and showed only a recency effect. With a visually presented version (written), the performance of these patients was better. Luria explained the findings as being due to retroactive inhibition of the earlier elements in audioverbal memory. Others (Basso, Spinnler, Vallar, & Zanobio, 1982; Warrington, Logue, & Pratt, 1971) have reported on patients with lesions in the left hemisphere who had a very short auditory digit span but nearly normal visual span, whereas expressive language functions were intact.

Studies in experimental psychological literature on the comparison between auditory and visual presentation of free recall lists have shown that auditory presentation leads to somewhat enhanced retention of the last words of the list (Engle, Clark, & Cathcart, 1980; Engle & Roberts, 1982; Rae, 1979; Watkins & Watkins, 1977). Unfortunately, most word-learning tests used in clinical neuropsychology are presented auditorily because visual presentation necessitates the use of a sophisticated apparatus, such as slide projectors and/or computers. Consequently, there is a lack of reliable methods to compare the learning capacity for words presented by either sensory modality.

The present study dealt with the comparison of auditory and visual modes of presentation of a word-learning test by way of tape recorder and microcomputer. The aim was to establish the efficacy of the procedure for later use in clinical neuropsychological practice (differentiation between patients with modality-specific memory deficits). Therefore, both modes of presentation were compared with respect to several parameters, such as the immediate and delayed recall, delayed recognition, learning curve, errors, and the rate of retrieval processes.

Method

Subjects

The subjects participating in the experiment were 12 graduate medical students (mean age = 25.7 years, SD = 3.8 years) who were paid for their services. The subjects were randomly assigned to the experimental groups.

Materials

The word-learning tests used were based on the Groningen 15-word learning test (Deelman, Brouwer, van Zomeren, & Saan, 1980). Seven versions of this test have been developed and shown to be parallel (Jolles, in preparation). Versions 3 and 4 were used in the present study. The learning list consists of 15 meaningful monosyllabic words. These words have a frequency of 20 to 400 per million according to the De la Court count of Dutch words (Linschoten, 1963) and refer to concrete objects, such as dog, moon, and bread. Also administered were recognition tests consisting of the 15 words from the corresponding learning list and 15 new but similar words drawn from the same population. The auditory presentation was done by tape recorder. The visual presentation was on a 33-cm monitor guided by a BASIS-108 microcomputer (Apple-compatible). The duration of each stimulus was 1 s for either presentation mode. Similarly, the interstimulus interval was 1 s. The words were composed of ASCII-type capital letters, 0.6 cm in height. They were presented in white against a black background and in the center of the screen.

Design

To study the difference between auditory and visual modes of presentation in immediate and delayed recall and recognition, we used a 2 × 2 × 2 between-subjects design. The dimensions were order of modality (visual-auditory, auditory-visual), order of version (3–4, 4–3), and session (first, second), with repeated measures over the last factor. The other parameters were studied in a within-subjects design.

Procedure

Each subject was tested individually. On arrival for the experiment, the subject was told that he or she would participate in a study of memory processes. Each subject sat at a table across from the experimenter during the auditory word-learning task. During the visual word-learning task, the subject confronted a television monitor at a distance of .8 m. For half of the

subjects, the order of tasks and events was the following: auditory word-learning task (aud) consisting of five trials, 20 min of distracting tests consisting of the discrimination of complex visual forms, delayed recall (aud), delayed recognition (aud), a short break, visual word-learning task (vis) consisting of five trials, 20 min of distraction (as above), delayed recall (vis), and delayed recognition (vis). The other half of the subjects received the tests in the order vis, aud.

The test instructions were read aloud by the experimenter. The subject was required to carefully listen to (and watch, respectively) the 15 words that were presented on the tape recorder (response monitor) and to mention as many words as possible as soon as the presentation stopped. There was no restriction on the output order. The first trial was followed by four more trials in which the words were presented in identical order. The subjects were instructed, in case of doubt, not to ask the experimenter if they had reported a word previously, although no pertinent instruction was given about whether it was allowed to repeat words already reported.

The verbal responses were recorded on a second tape recorder to allow the determination in the interval between the words recalled, or the interresponse time (IRT). This analysis was performed by the microcomputer.

When the immediate recall following the fifth trial was completed, the subject had to engage in the distracting tasks. After 20 min the instruction was given to actively recall the words learned (delayed recall). This was followed immediately by a delayed recognition test, involving yes/no recognition of the 15 words intermixed in 15 different distracting words. The items in the visual recognition task were presented on the screen in a self-paced fashion with a one-second response-stimulus interval; in the auditory condition they were read aloud by the experimenter. The binary choice was given by a vocal response in the auditory condition and by way of push buttons in the visual test ("yes" response by the preferred hand and "no" by the other hand). The reaction times were registered for the visual mode only. The data were statistically tested by using analysis of variance—ANOVA (Winer, 1971)—or by nonparametric methods—Wilcoxon test, Walsh test, Friedman's ANOVA (Siegel, 1968).

Results

A two-way ANOVA was carried out to assess the significance of the difference between auditory and visual modes of presentation with respect to the total score (the sum of Trials 1 through 5), delayed recall, and delayed recognition. No significant differences were found for any of these three parameters: There was no effect due to modality, order of version, and session; and there were no significant interactions. A second analysis was performed with order of modality, modality, and trials (five levels) as factors

and repeated measures over modality and trials. It appeared that trials was the only significant factor, $F(4, 40) = 91.82, p < .001$. No interactions with modality were observed. The learning curves for auditory versus visual presentation are given in Figure 1.

It is readily apparent that the curves representing auditory and visual presentations coincide. T tests on the scores for the individual trials were not significant. With respect to the learning curve, tests on the difference between pairs of means, according to the Newman-Keuls method (Winer, 1971), revealed a significant increase in learning between Trials 1 and 2, 2 and 3, and 3 and 5. In view of the possibility that a subtle difference in performance on both modes of presentation might reflect itself in the rate at which the words are recalled, an analysis was performed on the intervals between the verbal responses, or the interresponse time (IRT). The medium IRT was calculated per subject and per trial. Figure 2 shows the median data for the groups of subjects.

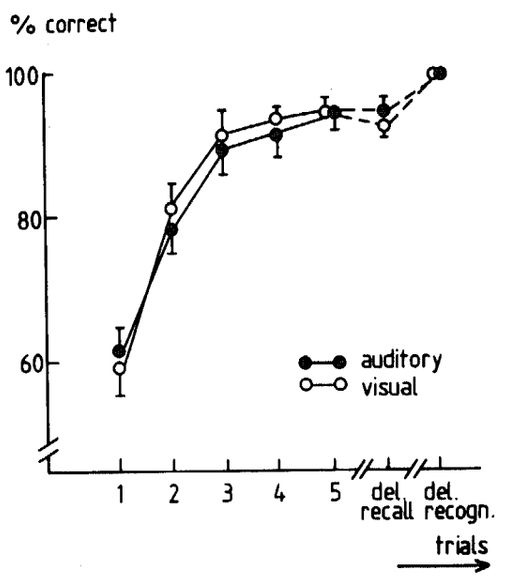

FIGURE 1. Learning curves. Mean performance ±1 *SD* per learning trial expressed as percentage of the maximum possible score (15 words recalled) in visual and auditory conditions.

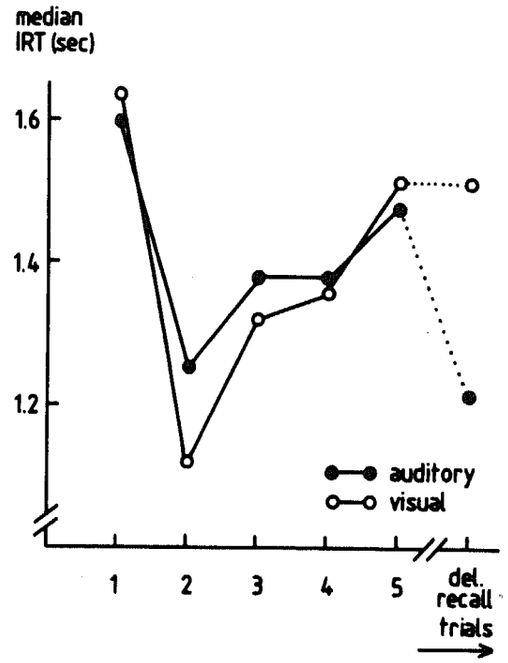

FIGURE 2. Median interresponse time. The median IRT was taken per subject and per trial; the median data for the group of subjects are depicted.

It appeared that the IRT significantly decreased between Trials 1 and 2 and increased between Trials 2 through 5 (Friedman's ANOVA). For the five trials in the learning phase, no differences were observed between the IRTs corresponding to auditory and visual presentations; a statistically significant difference was noted, however, in the delayed recall (Walsh test, $p < .011$). The median IRT in the auditory condition was 20% lower than in the visual condition. A post hoc analysis was carried out on the raw IRTs to assess the nature of the differential response. Figure 3 shows a frequency distribution of the IRTs in both modes of presentation. It appeared that the visual distribution was shifted toward shorter IRTs by .5 s.

The reaction times measured in the delayed recognition test could not be compared between the two modality conditions because of differences in the paradigm used. It was, however, observed that in the visual condition the RTs for the positive ("yes") responses were significantly shorter than

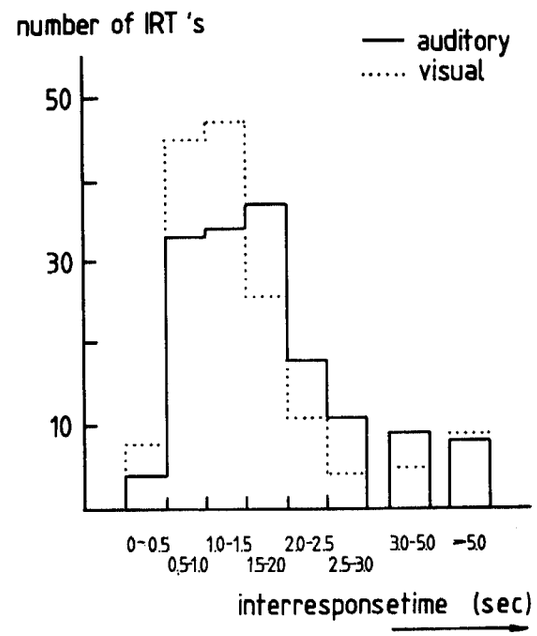

FIGURE 3. Frequency distribution of interresponse times. A comparison between auditory and visual interresponse times. The IRTs were summated per duration period.

those for the negative responses (Wilcoxon test, $p < .05$). This may have been due to the use of the nonpreferred hand for the "no" responses.

With respect to the number of errors of commission made in the learning trials, no statistically significant effects were found between both modes of presentation. Significantly more errors of repetition were made, however, in the visual condition (Wilcoxon test, $p < .05$): The median number of repetitions across subjects was 4.0, compared to 1.5 in the auditory condition.

Discussion

The main findings reported in the present study support the notion that the number of words recalled in healthy subjects is the same when the words are presented auditorily or visually. The two conditions were not different with

respect to the learning curves over the five learning trials. The total scores and the delayed recall and delayed recognition scores were also the same. In addition, the serial position curve for the first trial was very similar for the auditory and visual presentations. (A clear-cut primacy effect was found involving the first three words in the lists and a dip at the fourth position; results are not shown.)

The auditory and visual learning curves manifested an equivalent rate of learning (Figure 1); the subjects reached a plateau at the third to fourth trial. Consequently, the learning curves thus found can be used as a comparison for the learning curves obtained from patients suffering from different kinds of memory deficit. This applies especially to patients suffering from frontal neocortex dysfunction, who are characterized by a flat learning curve (Luria, 1976).

The finding that the interresponse times measured in the learning phase were similar in the auditory and visual conditions (Figure 2) adds support to the conclusion reached above, that both conditions are equivalent with respect to the learning phase. The increase in median IRT measured from Trial 2 through 5 may reflect the increase in the number of words recalled. The significantly higher IRT in Trial 1 may have to do with the novelty of the words presented; it suggests that more time is needed to retrieve newly learned words. Further research should be directed at substantiating this interesting result. A similarly unexpected finding is the significantly lower IRTs needed for delayed recall of auditorily learned words, as compared to visually learned words. The median IRT for the delayed recall in the visual condition was on the level of the fifth learning trial, but that for the auditory delayed recall was reduced, compared to the fifth learning trial. This may indicate, in the first place, that the retrieval process in delayed recall is different from that in immediate recall. It is a common observation that many subjects start their immediate recall by mentioning the last words in the list, whereas the order in which the words are recalled in the delayed recall more or less follows the sequence in which they were presented. In the second place, the observed difference between auditory and visual delayed recall may indicate that the retrieval process after a delay of 20 min is easier after auditory presentation. Neuropsychologically, speaking a word that is seen requires a different cerebral route than speaking a word that is heard (Luria, 1980; Marcel & Patterson, 1978). The present data support the notion that the former route is less direct, which is evident in the longer retrieval time needed to recall these words. This hypothesis is presently being investigated in a follow-up experiment, specially designed for this purpose.

Another indication for a qualitatively and quantitatively different retrieval process in both conditions is the significantly greater number of errors of repetition in the visual condition (nearly three times as many errors). This may indicate that the words already mentioned are not very effectively

discarded from the *output buffer* in which the words are circulating before being spoken aloud. This adds support to the notion that there is a difference in the neuropsychological organization of auditory versus visual word-learning processes.

In conclusion, the results obtained in this study show that, in healthy subjects, auditory and visual presentation of a word-learning test gave equivalent results with respect to the number of words recalled in immediate and delayed recall and recognition. More subtle differences did exist between both conditions in that the performance with respect to rate of delayed recall and the number of errors of repetition was superior in the auditory condition. These results indicate that the test paradigm investigated in the present study can be applied to the assessment of patients suspected of modality-specific memory defects as described in the neuropsychological literature (Basso, Spinnler, Vallar, & Zanobio, 1982; Luria, 1976; Warrington, Logue, & Pratt, 1971). Technically, the use of a microcomputer appears to offer great advantages with respect to controlled stimulus presentation and reaction time measurement and, thus, promises to be of value for use in the clinic. Both modes of presentation are presently being tested with neuropsychiatric patients. Preliminary results indicate that schizophrenic patients manifested a quite considerable discrepancy between total recall and delayed recall for auditory and visual presentations. The other patients thus far investigated had a close correlation between both modes of presentation (Jolles & Brand, unpublished observations).

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Received January 2, 1985

The Journal of General Psychology, 112(2), 211–219

The Influence of Embellishment and Prequestions on Free Recall of a Text

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ABSTRACT. The influence on free recall of the addition of embellishing details to the constituent scenes of a text was studied as a function of the salience of the embellished scenes within the overall content. The relative salience of the scenes that occupied odd- or even-numbered serial positions was varied by introduction of prequestions. In Experiment 1 (n = 52), the effectiveness of the prequestions was tested, in Experiment 2 (n = 48), the presentation of prequestions was combined orthogonally with embellishment of the scenes. The results indicate that the effects of prequestions and embellishment appear to be additive. Embellishment of half of the scenes appears to be most effective when the salience of the relevant scenes has been enhanced by presentation of appropriate prequestions.

WHEN SUBJECTS RECALL a previously studied text, they are apt to omit a considerable portion of the originally learned material, which nonetheless may appear accessible under suitable conditions. For instance, relatively high recognition scores may be found in cases in which free recall fails. Anderson and Pichert (1978) have shown that a change of perspective in the subject prior to recall may result in enhanced retrieval of information that is congruent with the new point of view. Also, occasional interruptions of the process of free recall to urge the subjects to reproduce the text more completely appears to be a method of producing an increase in the amount of recalled information (Van Dam & Brinkerink-Carlier, 1983a).

Generally, knowledge about the influence of retrieval cues on prose recall is limited (Johnson, 1982). In this respect, it is interesting to note a

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